X-552-67-540

THE DETERMINATION AND COMPARISON OF THE GRARR MADGAR SITE LOCATION

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October 1967

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Greenbelt, Maryland

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ABSTRACT

Improved coordinates for the MADGAR range and range rate site have been estimated from GEOS-I data sets using the NONAME orbit determination program. These coordinates have been compared with a preliminary estimate obtained under contract with Goddard Space Flight Center by the Applied Physics Laboratory using thirty-nine passes of SRN-9 Doppler data from three satellites.

Two independent estimates were obtained using the NONAME orbit determination program; one estimate was obtained from optical flash sequence data taken at 1TANAN (MOTS 40" camera) during July 1966 and the other from range measurements taken at MADGAR during November 1965. These two estimates of the site location are within five meters of each other; whereas the Applied Physics Laboratory estimate is separated by fifty meters, mainly in longitude.

The comparison of the Applied Physics Laboratory MADGAR location estimate with the optically determined NONAME estimate is shown by plots of the residual differences of the range and range rate measurements from five reference orbits. The five reference orbits were determined solely from optical flash sequence data, and they had a maximum root mean square of fit of less than two seconds of arc. The residual difference for both range and range rate measurements clearly indicate that a significantly better set of MADGAR coordinates was obtained from the NONAME orbit determination program.

Table I

Estimated MADGAR C-5 Station Coordinates
(GRARR S-band Antenna)

	Latitude	East Longitude	Spheroid Height
Optical estimate	-19° 1' 19.5"	47° 18' 7.9"	1380.0 meters
GRARR estimate	-19° 1' 19.4"	47° 18' 8.0"	1382.6
APL estimate	-19° 1' 19.5"	47° 18' 6.2"	1381.0

(The C-5 ellipsoid semi-major axis is 6,378,165 meters and the flattening is 1/298.25)

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THE DETERMINATION AND COMPARISON OF THE GRARR MADGAR SITE LOCATION

1.0 INTRODUCTION

The coordinates of the two STADAN tracking stations in Tananarive, Madagascar were estimated separately using two independent data sets. The stations are the MOTS 40" camera station 1TANAN, and the GRARR station MADGAR.

The new locations were estimated using the NONAME Orbit Determination Program[1]; the data used in the estimation process was tracking data from SAO Baker-Nunn cameras, STADAN MOTS 40" cameras, and a STADAN Range and Range Rate instrument. The location of each station was estimated separately using independent data sets; a data set from July, 1966, was used to estimate 1TANAN, and another from November, 1965, was used to estimate MADGAR.

The estimated locations are shown in Table II; the shifts between the original and estimated coordinates were 6.9 seconds in latitude for 1TANAN and 6.8

Table II

Coordinates of 1TANAN and MADGAR

Latitude	1TANAN			MADGAR		
	Deg.	Min.	Secs.	Deg.	Min.	Secs.
Original location	-19	0	26.4	-19	1	12.6
Estimated location	-19	0	33.3	-19	1	19.4
Shift			+ 6.9			+ 6.8
East Longitude						
Original location	47	17	59.2	47	18	8.2
Estimated location	47	17	58.9	47	18	8.0
Shift			- 0.3			- 0.2
Spheroid Height (Meters)						
Original location		1305.5			1329.5	
Estimated location		1355.9			1382.6	
Shift		50.4			53.1	

[1]The NONAME orbit determination program was developed under NASA contract by Wolf Research and Development Corporation for the Mission and Trajectory Analysis Division (Reference 1).

seconds for MADGAR, in East longitude -0.3 seconds and -0.2 seconds, respectively, and in spheroid height 50.4 meters and 53.1 meters, respectively. Thus, the relative location of the two stations has only changed slightly. The shifts between the original coordinates and the estimated coordinates of 1TANAN were applied to the original MADGAR coordinates to obtain the optical estimate of the MADGAR location.

2.0 DETERMINATION OF STATION LOCATIONS

Orbits were estimated from two data sets using the NONAME Orbit Determination Program, operating in the data reduction mode. The program used a Bayesian least squares technique to estimate six orbital parameters and the three coordinates of the station being estimated.

The following data sets were used:

(1) July 9, 10 and 11, using 730 measurements.
(2) November 28 and 29, using 598 measurements.

The majority of the measurements were from SAO Baker-Nunn camera stations; the remainder were from STADAN MOTS 40" camera stations and MADGAR GRARR.

The coordinates of 1TANAN were estimated using data set (1), and the coordinates of MADGAR were estimated using data set (2). A representation of the geometry of the passes over 1TANAN and MADGAR is given in Figure 1. Summaries of the data sets are given in Tables III and IV.

3.0 COMPARISON OF STATION LOCATIONS

To compare the new locations, the original, NONAME, and APL coordinates[2] of MADGAR were used in turn to obtain the residual differences for ten passes of GRARR observations from five reference orbits.

The reference orbits were estimated using optical data only, and they all had an rms of fit of 2 seconds of arc or less. The following periods and data sets were used:

(1) November 23 and 24, 1965 using 519 measurements.
(2) November 27, 28 and 29, 1965 using 826 measurements.

[2]This is a preliminary result obtained by APL under a NASA contract from the Mission and Trajectory Analysis Division.

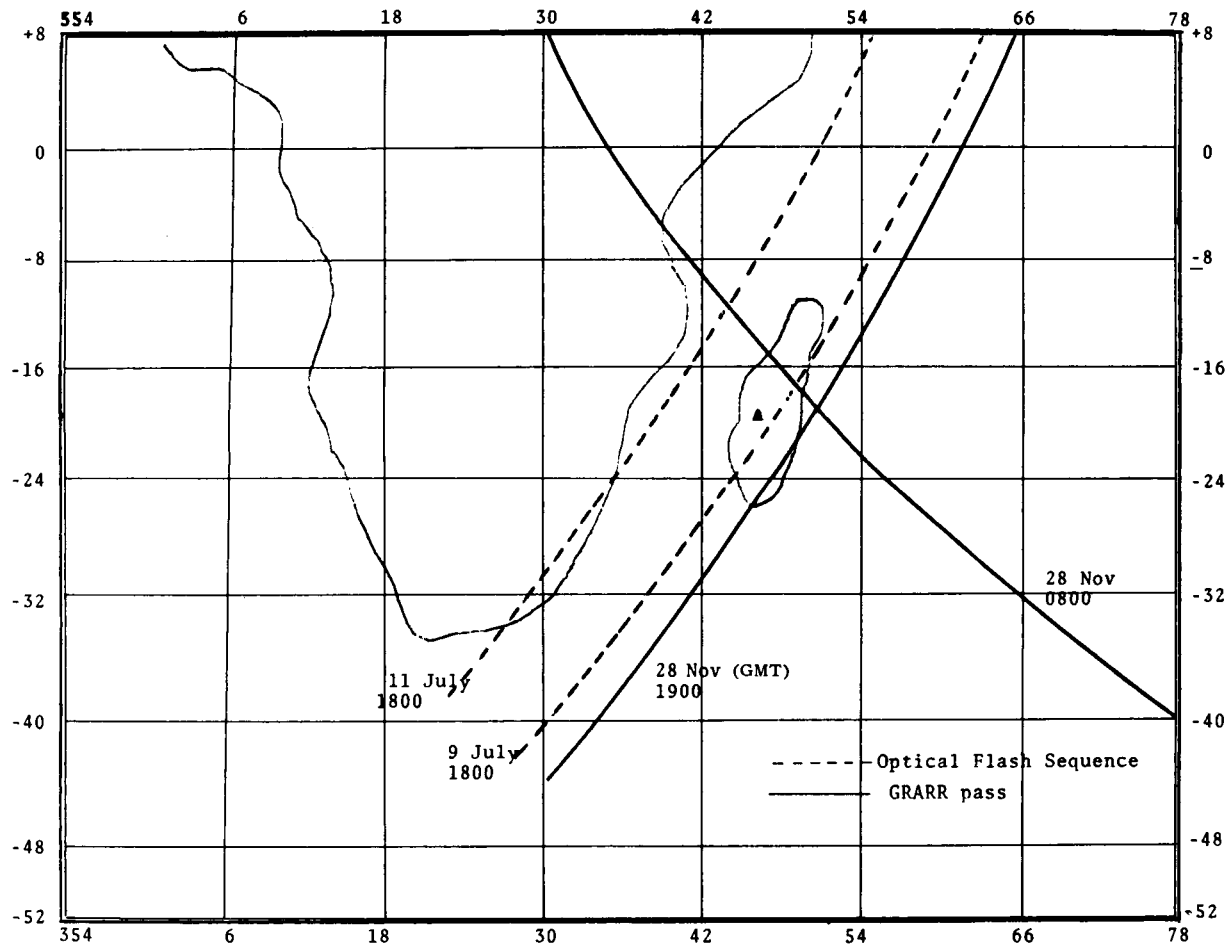


Figure 1. Optical and GRARR Passes over Tananarive

Table III

Summary of Data by Station for July 9, 10, and 11

Station	No. of Measurements	
	Right Ascension	Declination
1TANAN	14	14
1ROSMA	7	7
1COLBA	14	14
1BPOIN	14	14
1DENVR	20	20
1JOBUR	14	14
1ORGAN	91	91
1OLFAN	28	28
1SPAIN	21	21
1QUIPA	28	28
1CURAC	28	28
1JUPTR	35	35
1VILDO	7	7
AUSBAK	14	14
1MAUIO	28	28
EDWAFB	2	2
TOTAL	365	365

Table IV

Summary of Data by Station for November 28 and 29

Station	No. of Measurements	
	Right Ascension	Declination
1ORGAN	59	59
1OLFAN	1	1
1SPAIN	1	1
1QUIPA	2	2
1CURAC	96	96
1JUPTR	127	127
1VILDO	1	1
TOTAL	287	287
	Range	
MADGAR	24	

(3) November 28 and 29, 1965 using 574 measurements.
(4) July 17 and 18, using 780 measurements.
(5) July 22, 23 and 24, using 641 measurements.

Summaries of these data sets are given in Tables V - IX.

Table V

Summary of Data by Station for November 23 and 24

Station	No. of Measurements	
	Right Ascension	Declination
1EDINB	17	10
1FTMYR	41	44
1PURIO	19	19
1BPOIN	11	13
BEDFRE	13	13
1ORGAN	62	55
1CURAC	59	51
1JUPTR	34	34
1COLBA	4	2
1OLFAN	3	2
1SPAIN	2	2
1QUIPA	1	1
1VILDO	3	3
AUSBAK	0	1
TOTAL	269	250

The geometry of the ten GRARR passes during these periods is shown in Figures 2 and 3. The residual differences obtained using the three locations are summarized in Figures 4-23. The range residuals in these figures have been corrected for refraction, transponder delay, and known cable bias; no corrections were applied to the range rate residuals. Figures 4-23, clearly indicated that the NONAME estimated coordinates are a significant improvement on the other two sets.

The residuals obtained using the NONAME location are smaller in sixteen out of the twenty plots, by as much as 45 meters in range and 50 cm/sec in range rate in some cases. In three of the plots the size of the residuals is approximately equal, and in one plot the residuals obtained using the APL location are slightly smaller. The sizes of the differences between the two sets of residuals correspond to the 50 meter separation in the longitude coordinate in combination with the pass geometry.

Table VI

Summary of Data by Station for November 27, 28 and 29

Station	No. of Measurements	
	Right Ascension	Declination
1EDINB	12	14
1FTMYR	21	21
1COLBA	10	11
1JUM40	6	6
1ORGAN	66	73
1SPAIN	1	1
1QUIPA	133	128
1JUPTR	169	148
1VILDO	2	2
AUSBAK	1	1
TOTAL	422	406

Table VII

Summary of Data by Station for November 28 and 29

Station	No. of Measurements	
	Right Ascension	Declination
1ORGAN	60	60
1OLFAN	1	1
1SPAIN	1	1
1QUIPA	2	2
1CURAC	96	96
1JUPTR	127	127
1VILDO	1	1
TOTAL	288	288

Table VIII

Summary of Data by Station for July 17 and 18

Station	No. of Measurements	
	Right Ascension	Declination
1JOBUR	13	13
1ORGAN	73	73
1OLFAN	31	31
1SPAIN	48	48
1QUIPA	21	21
1JUPTR	112	112
1VILDO	14	14
1MAUIO	29	29
AUSBAK	49	49
TOTAL	390	390

Table IX

Summary of Data by Station for July 22, 23 and 24

Station	No. of Measurements	
	Right Ascension	Declination
1ORGAN	145	163
1OLFAN	31	35
1SPAIN	31	35
1QUIPA	27	27
1VILDO	21	21
1MAUIO	15	13
AUSBAK	49	
TOTAL	319	322

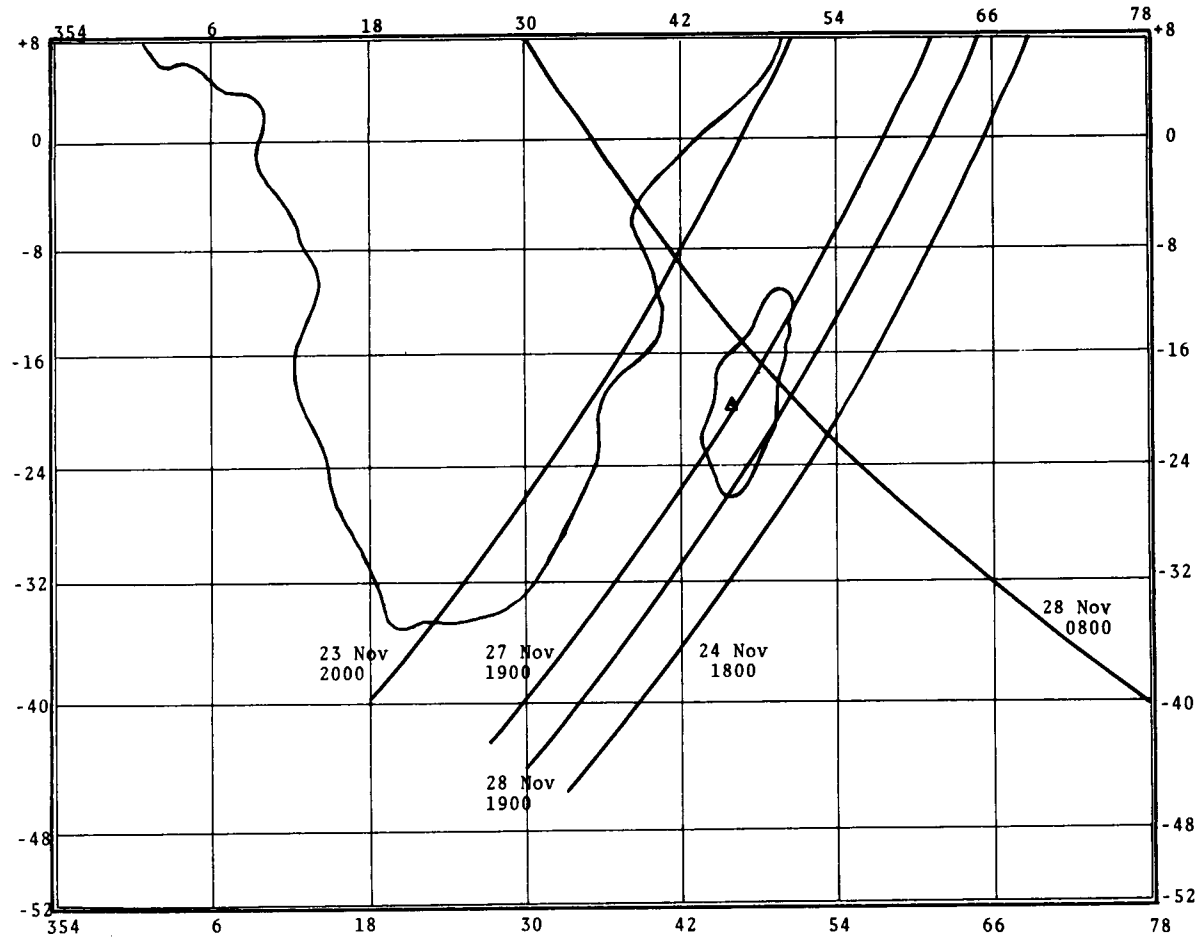


Figure 2. GRARR Passes over MADGAR

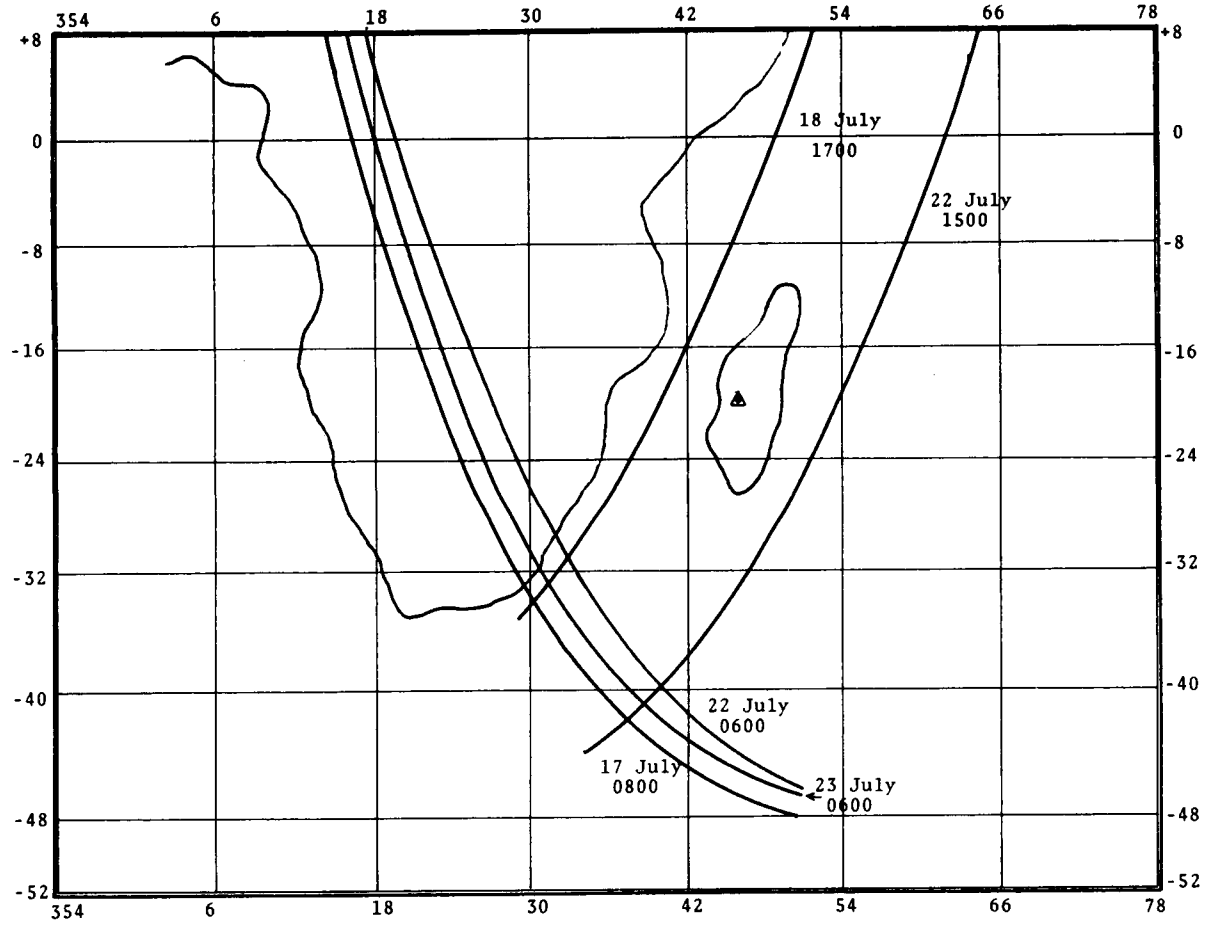


Figure 3. GRARR Passes over MADGAR

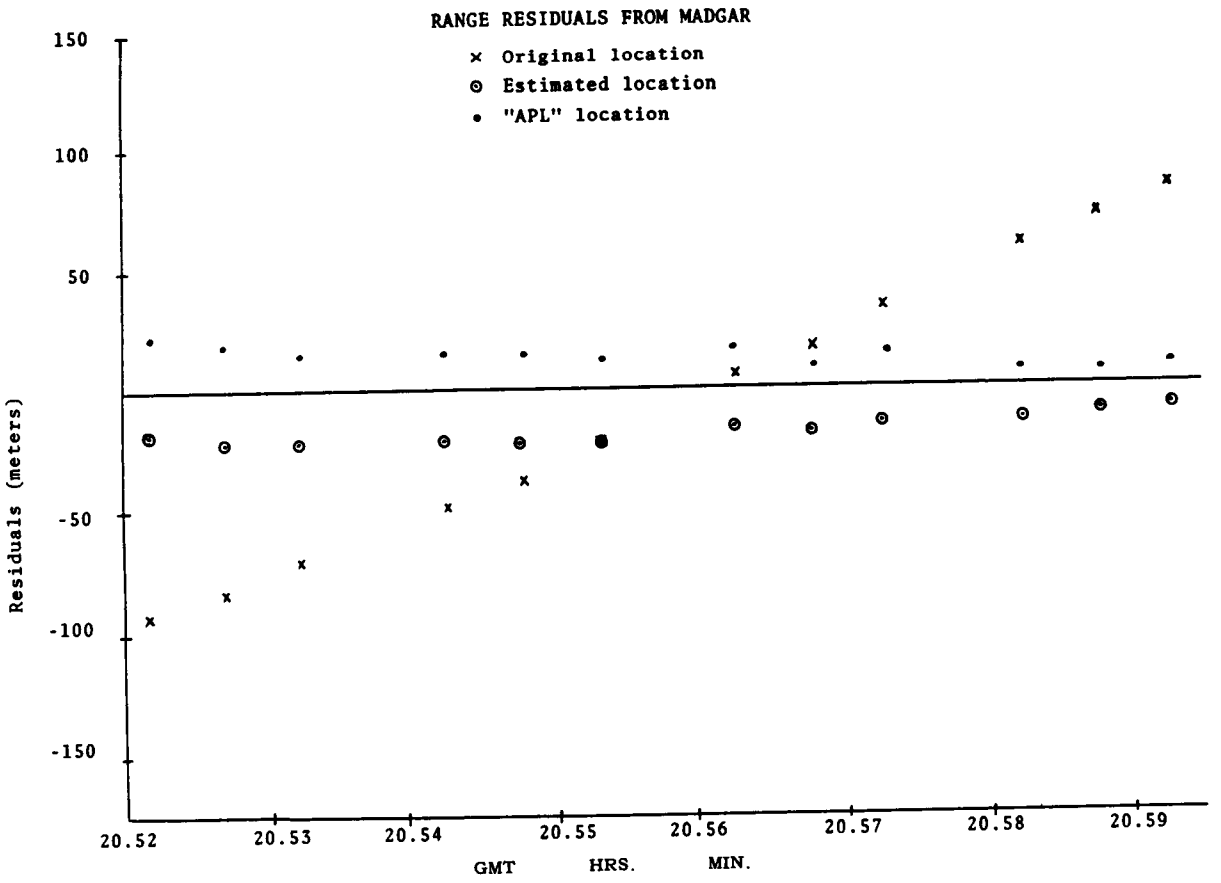
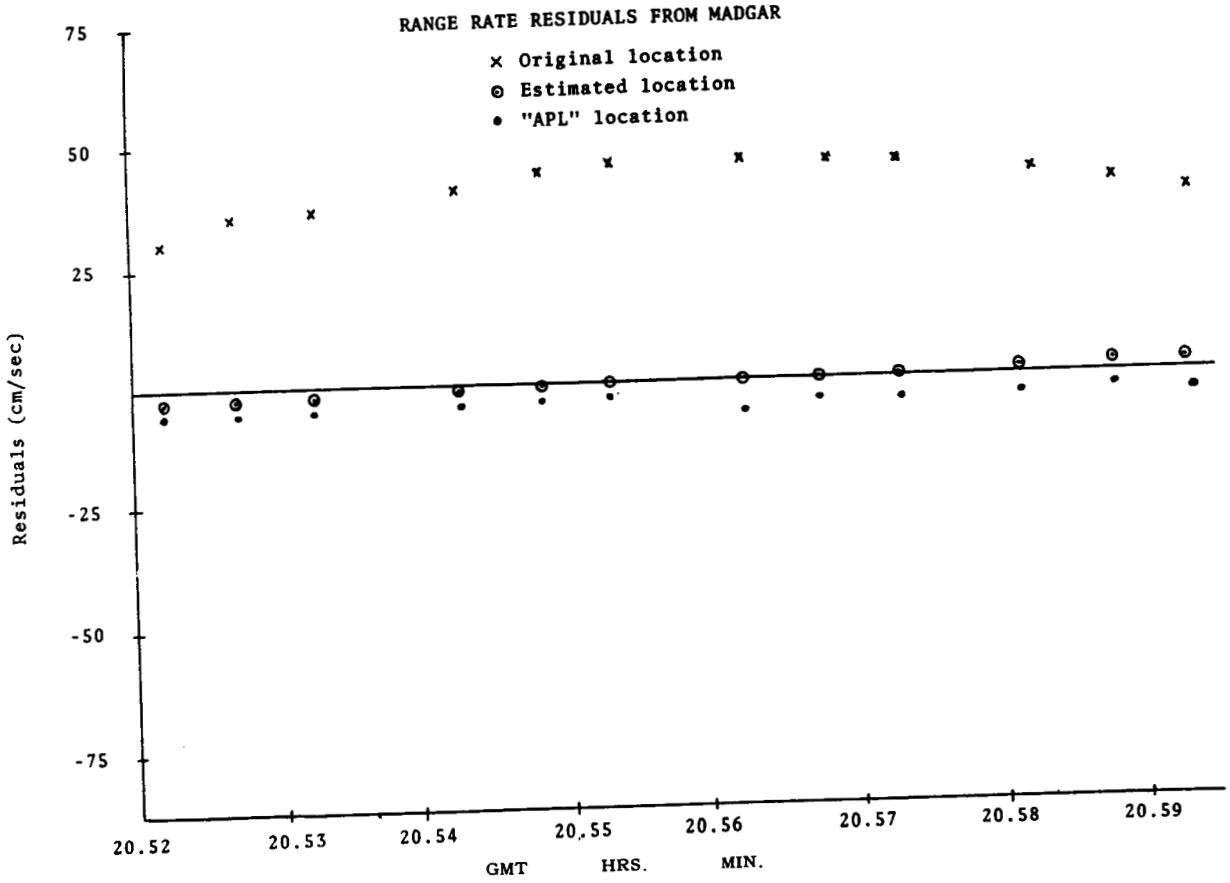


Figure 4. November 23, 1965



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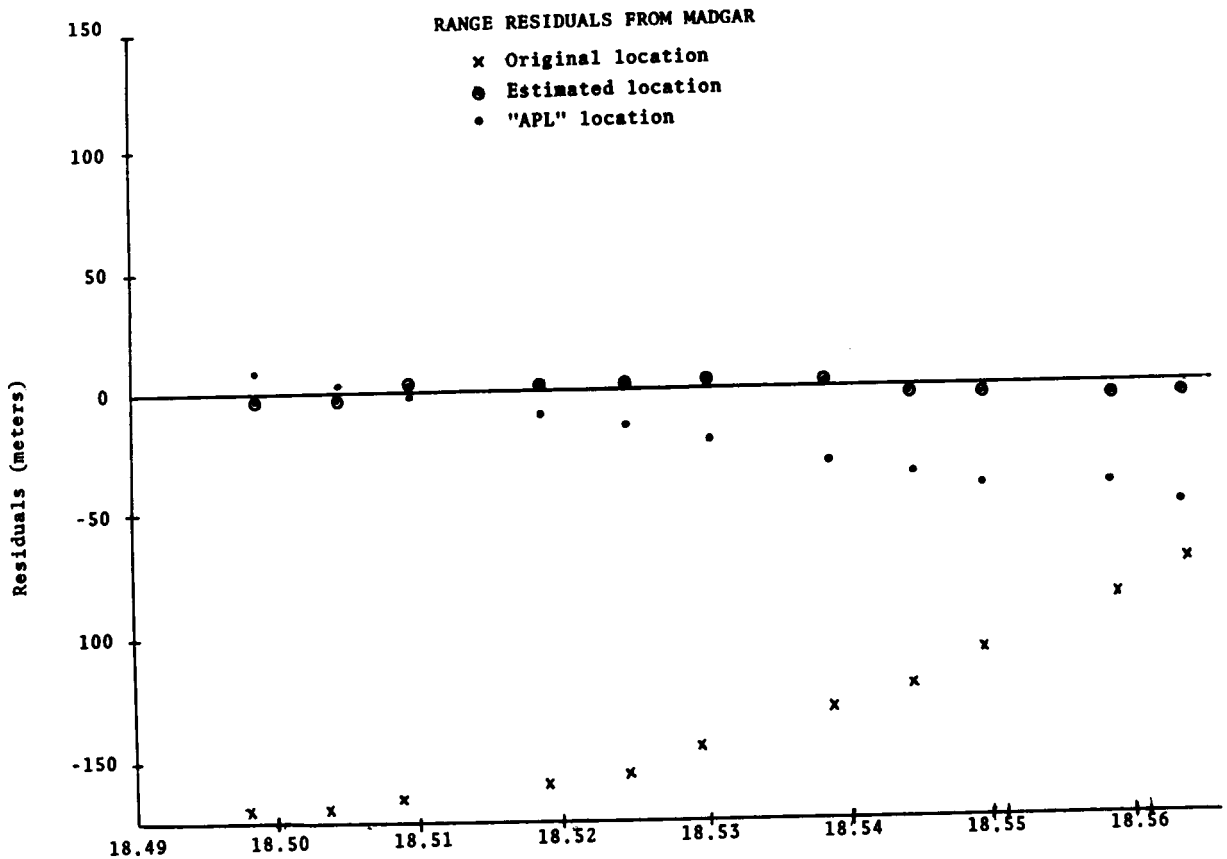

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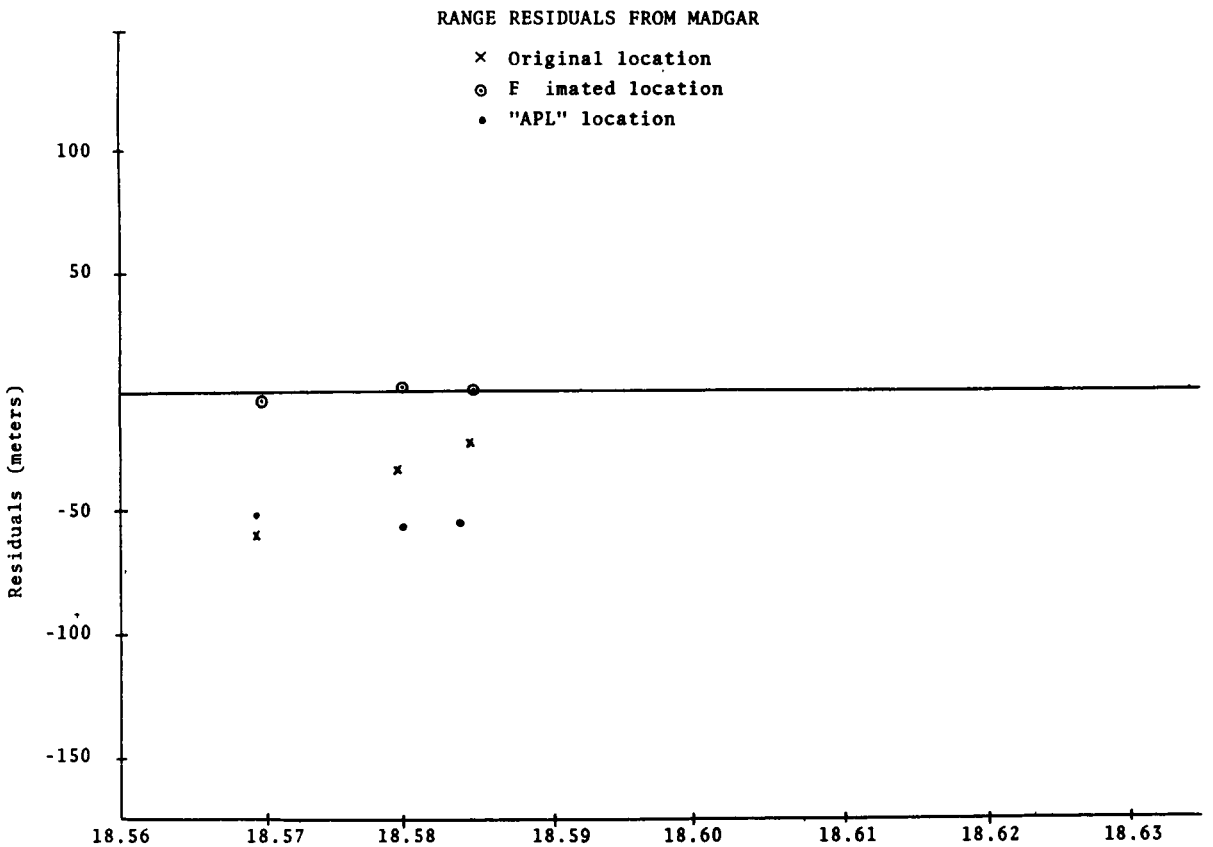

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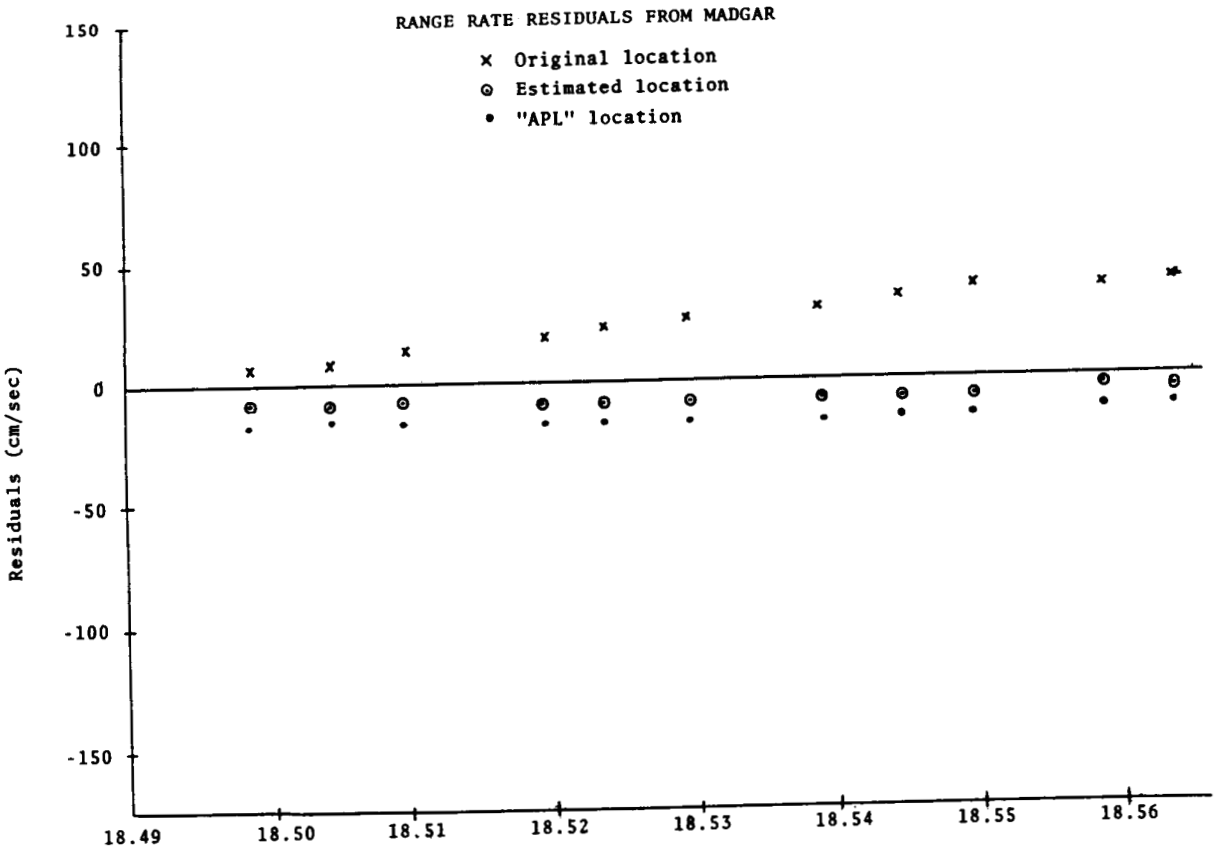

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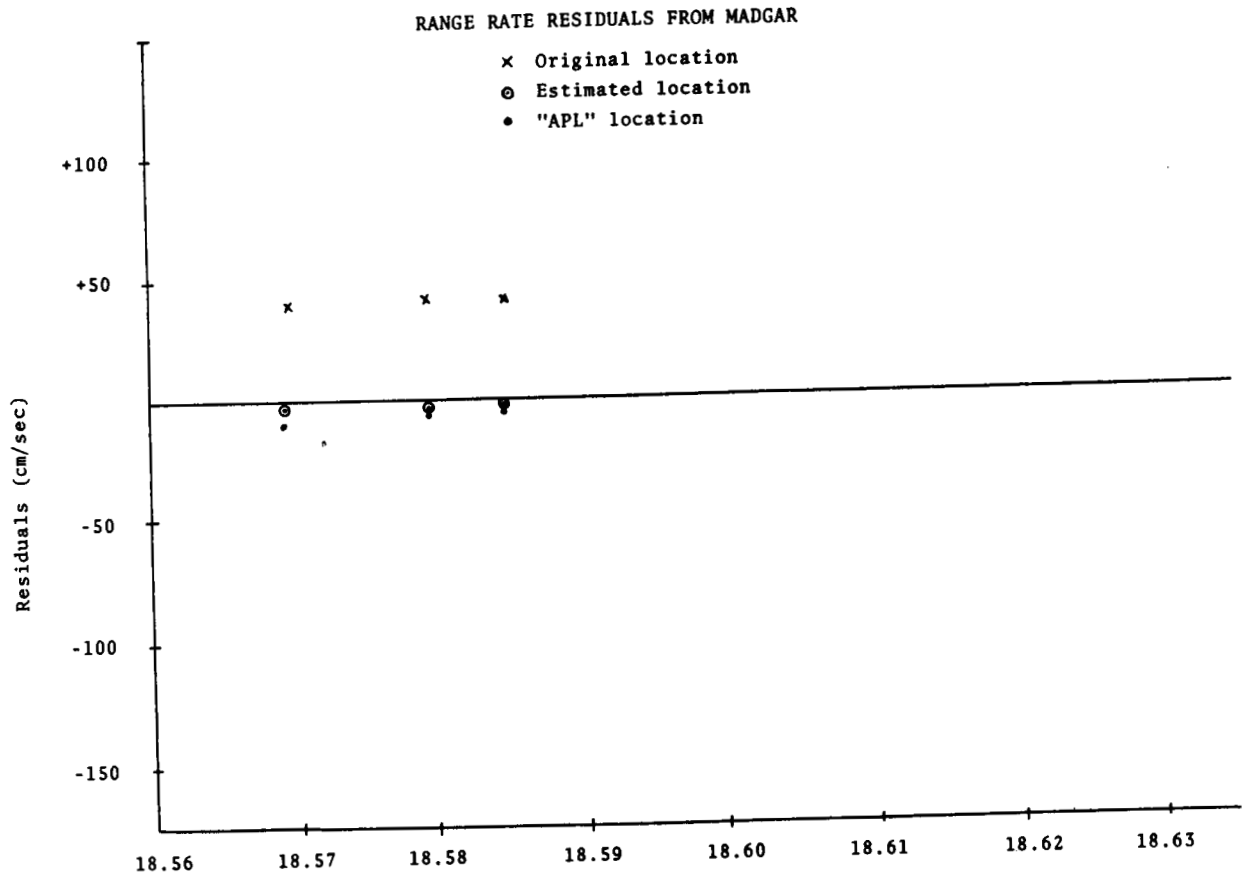

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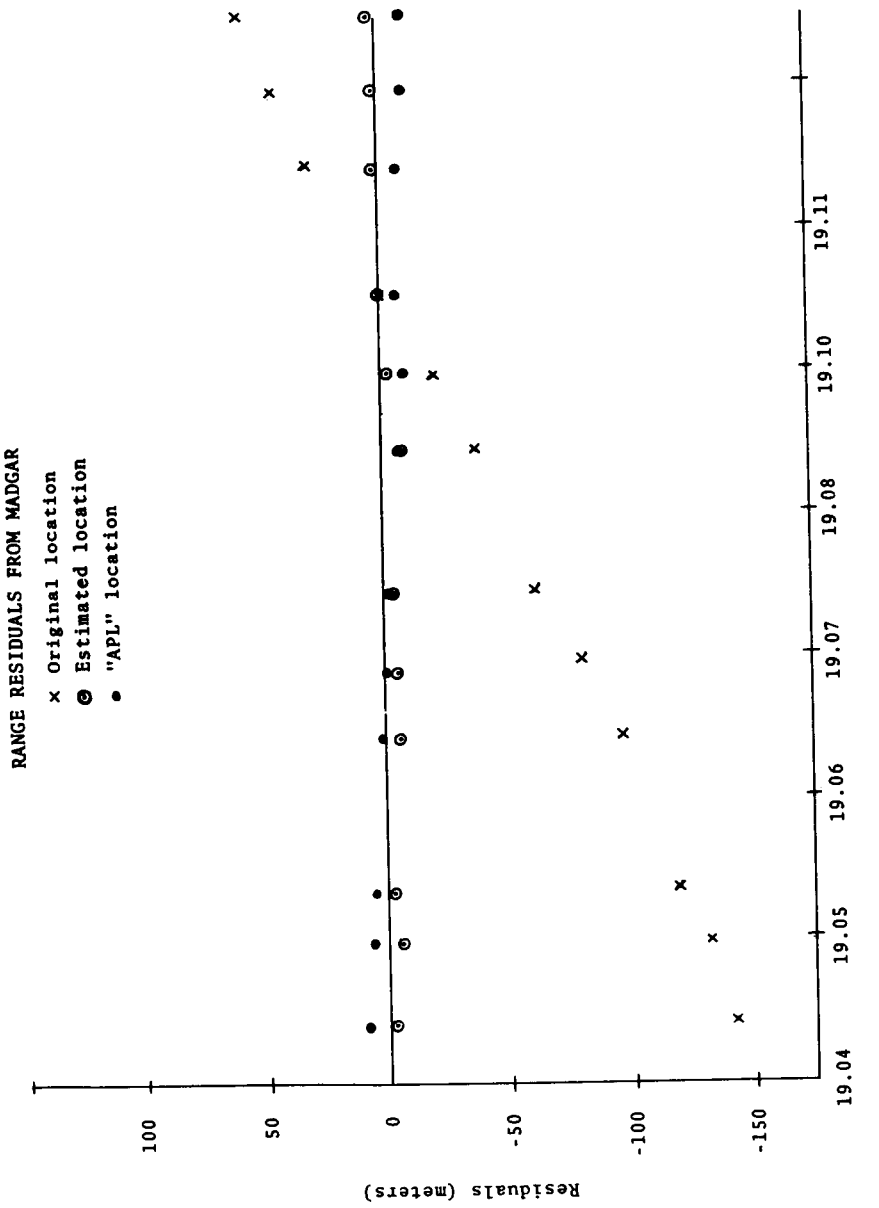
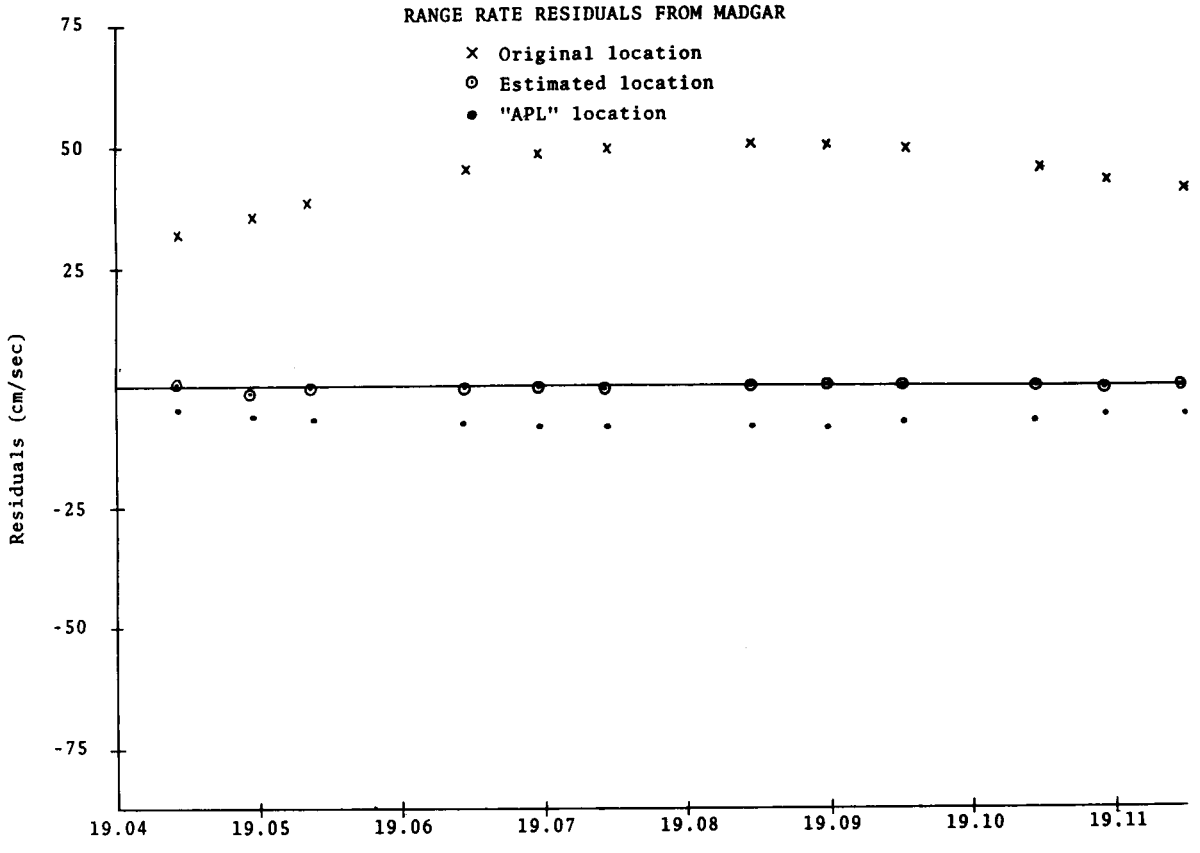


Figure 8. November 27, 1965



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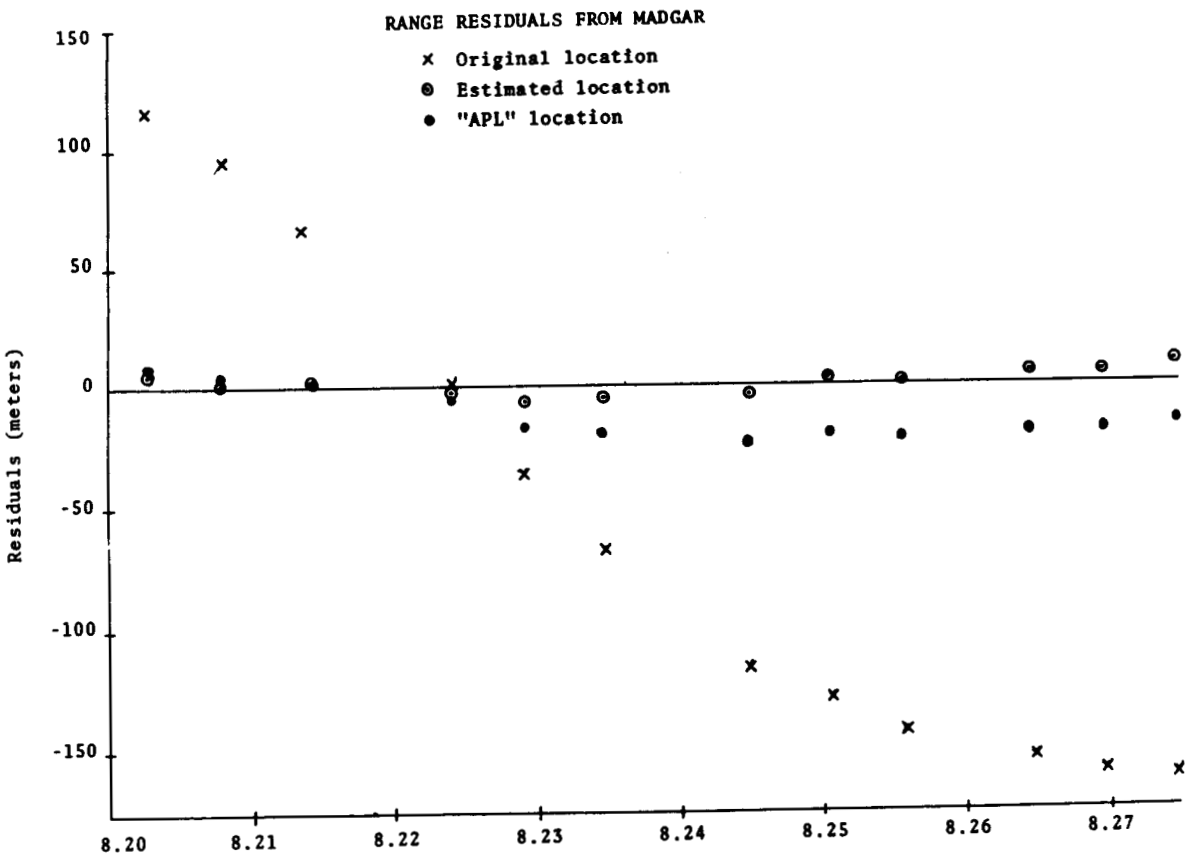
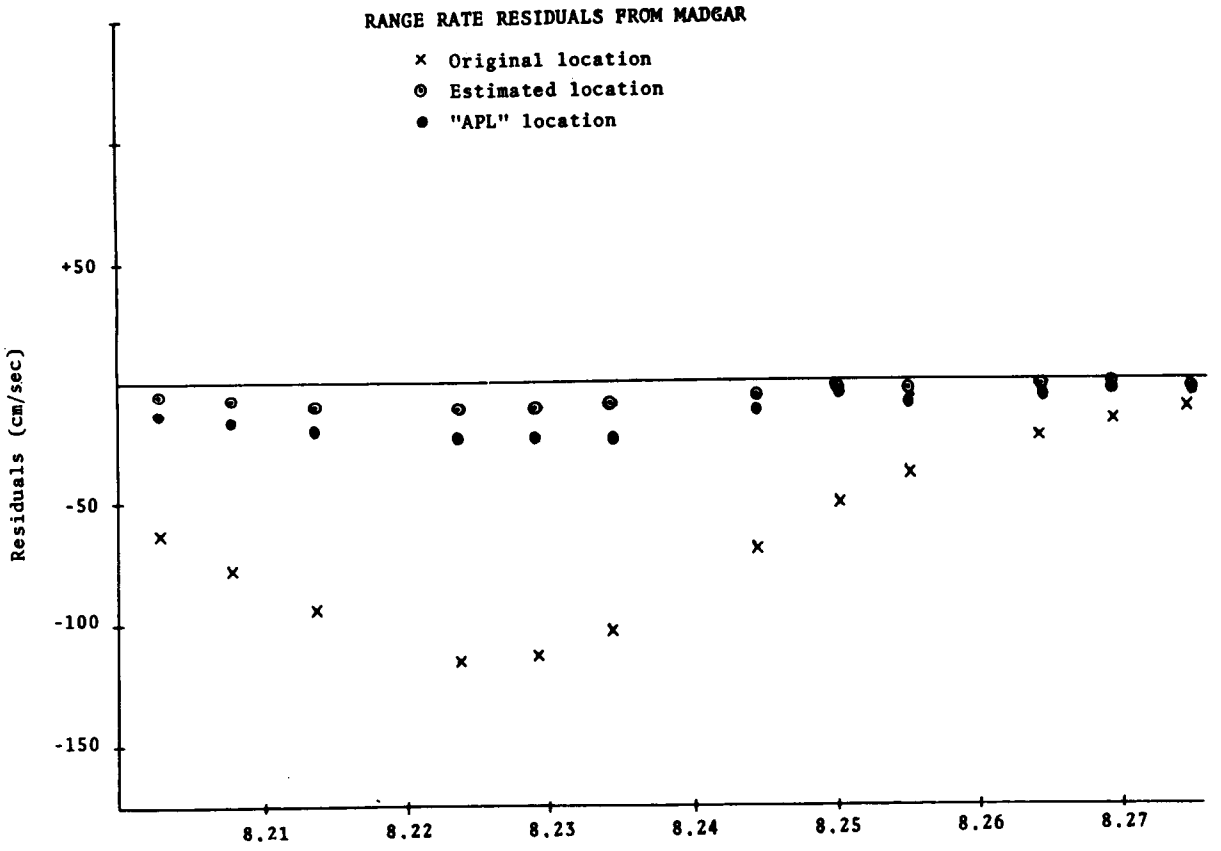


Figure 10. November 28, 1965



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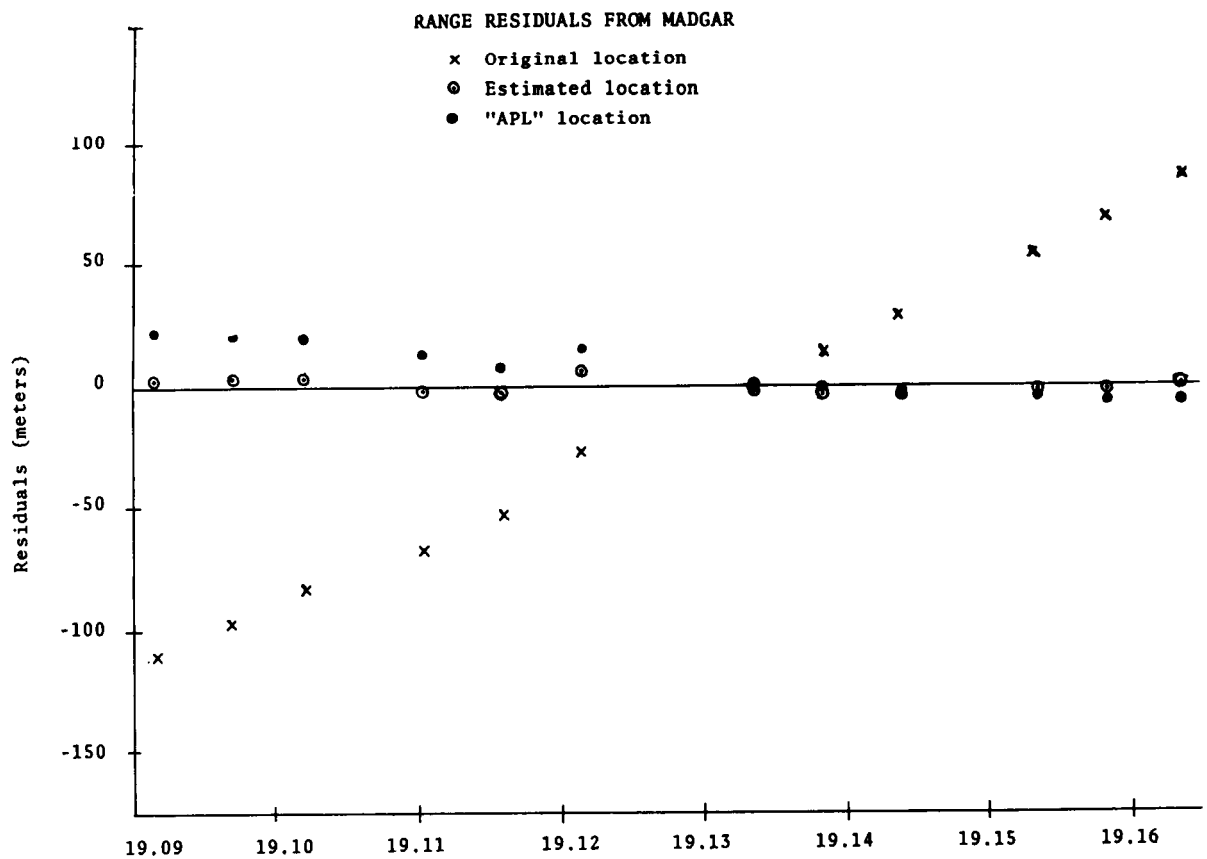

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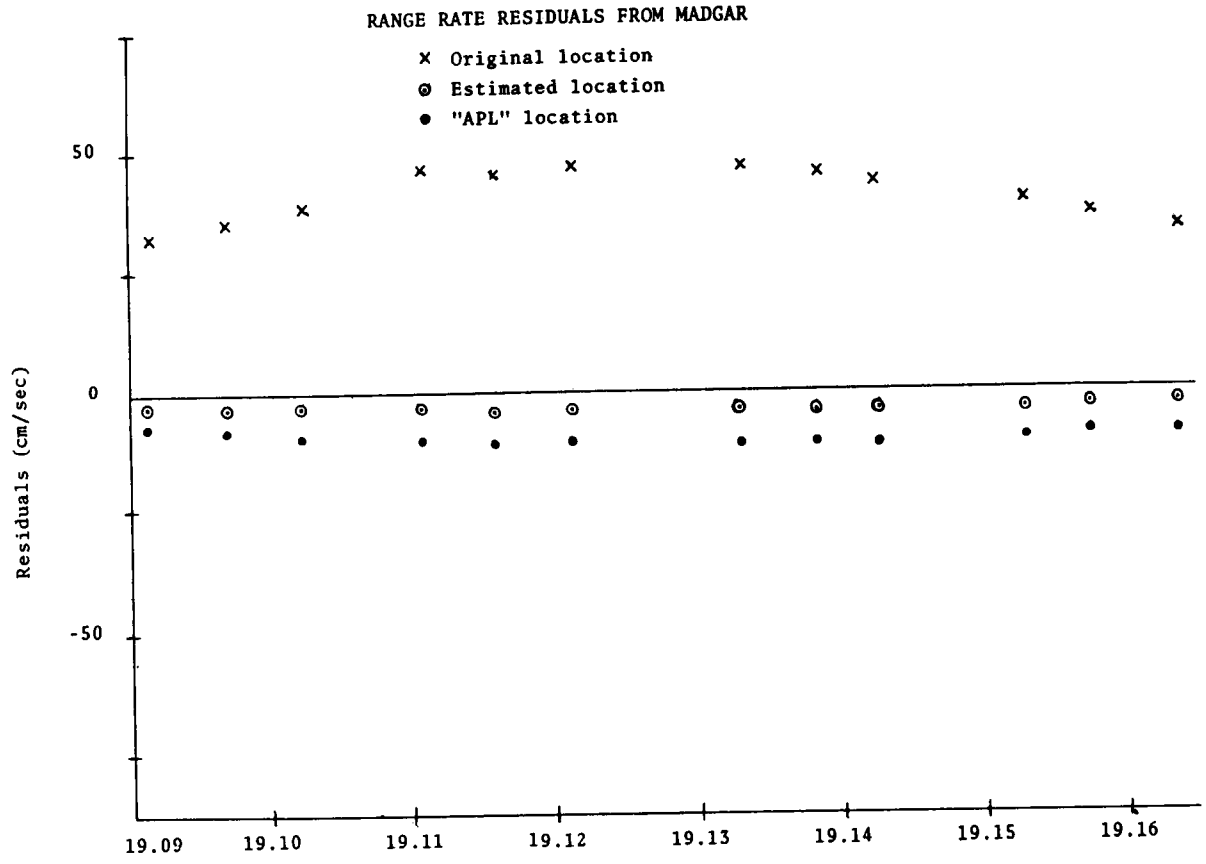

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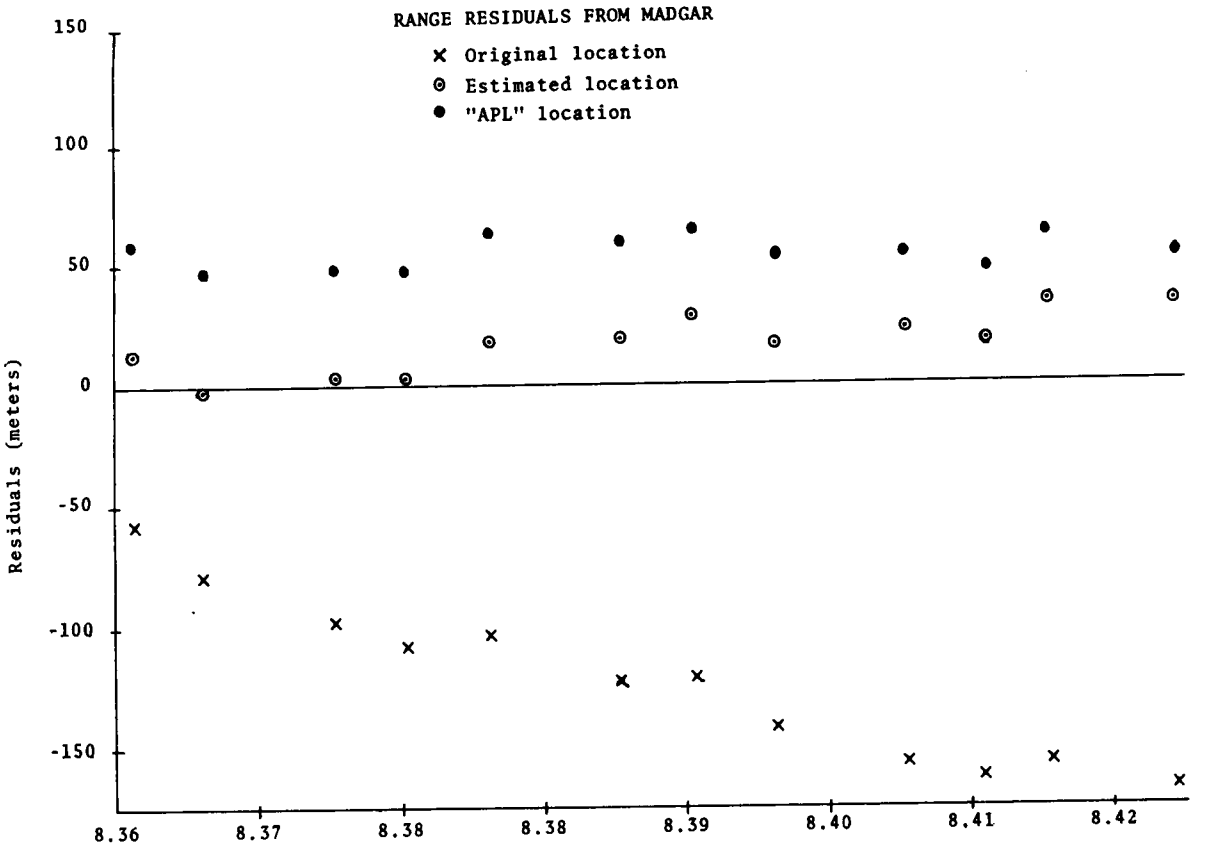


Figure 14. July 17, 1966

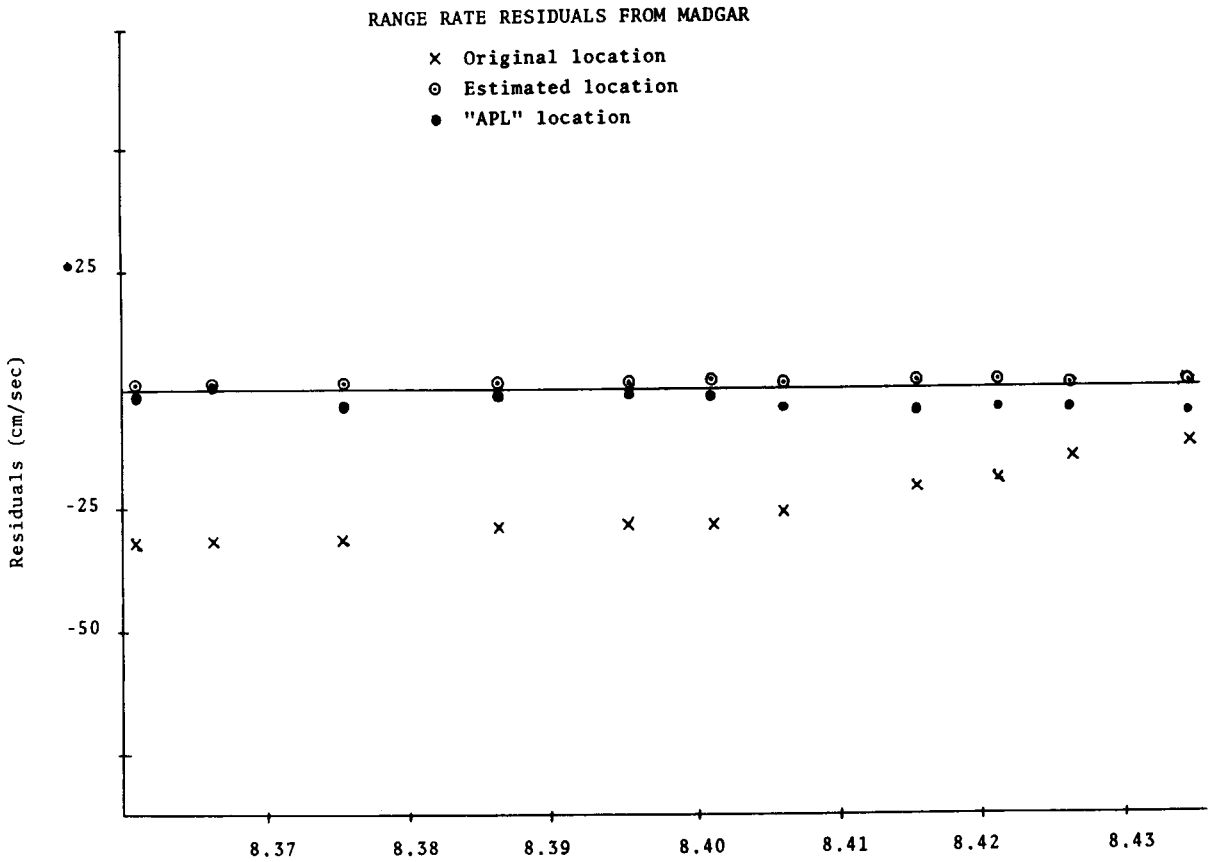
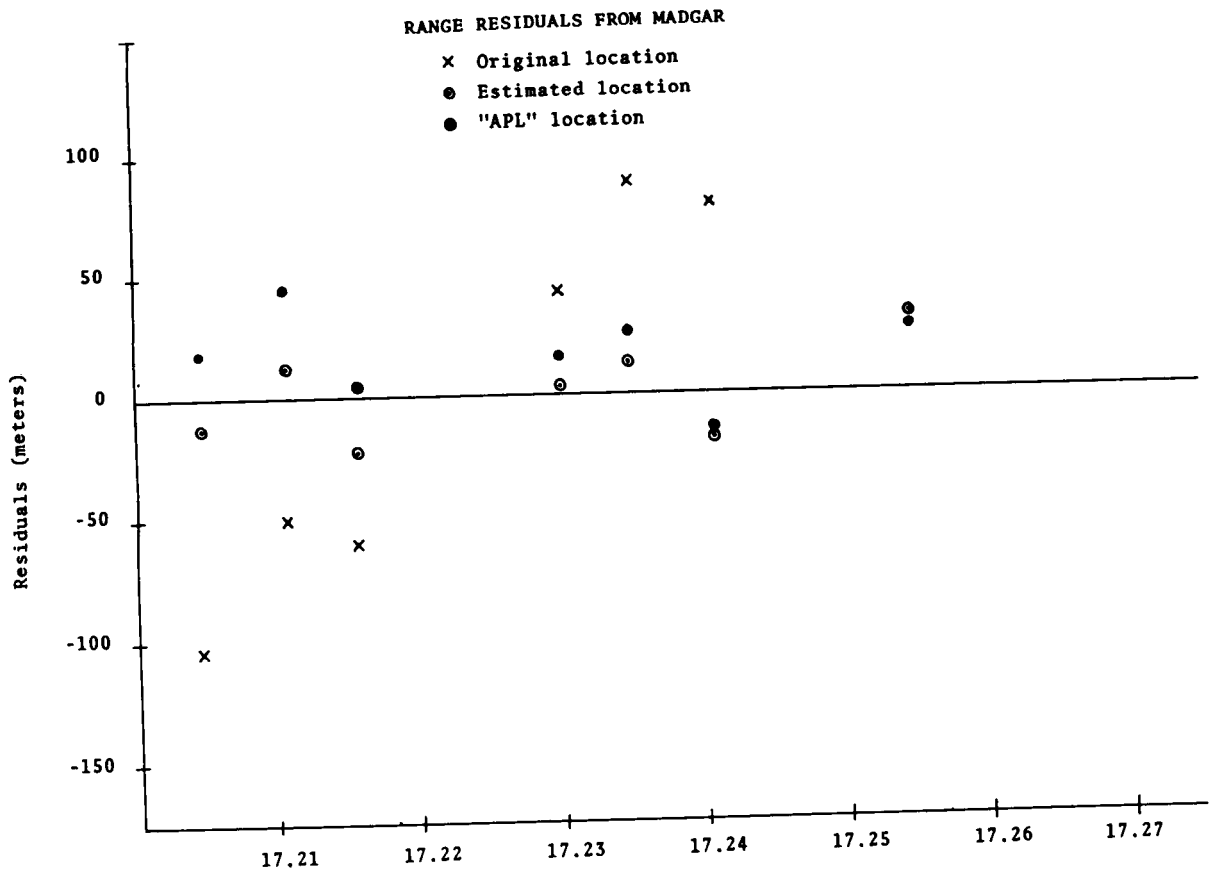


Figure 15. July 17, 1966



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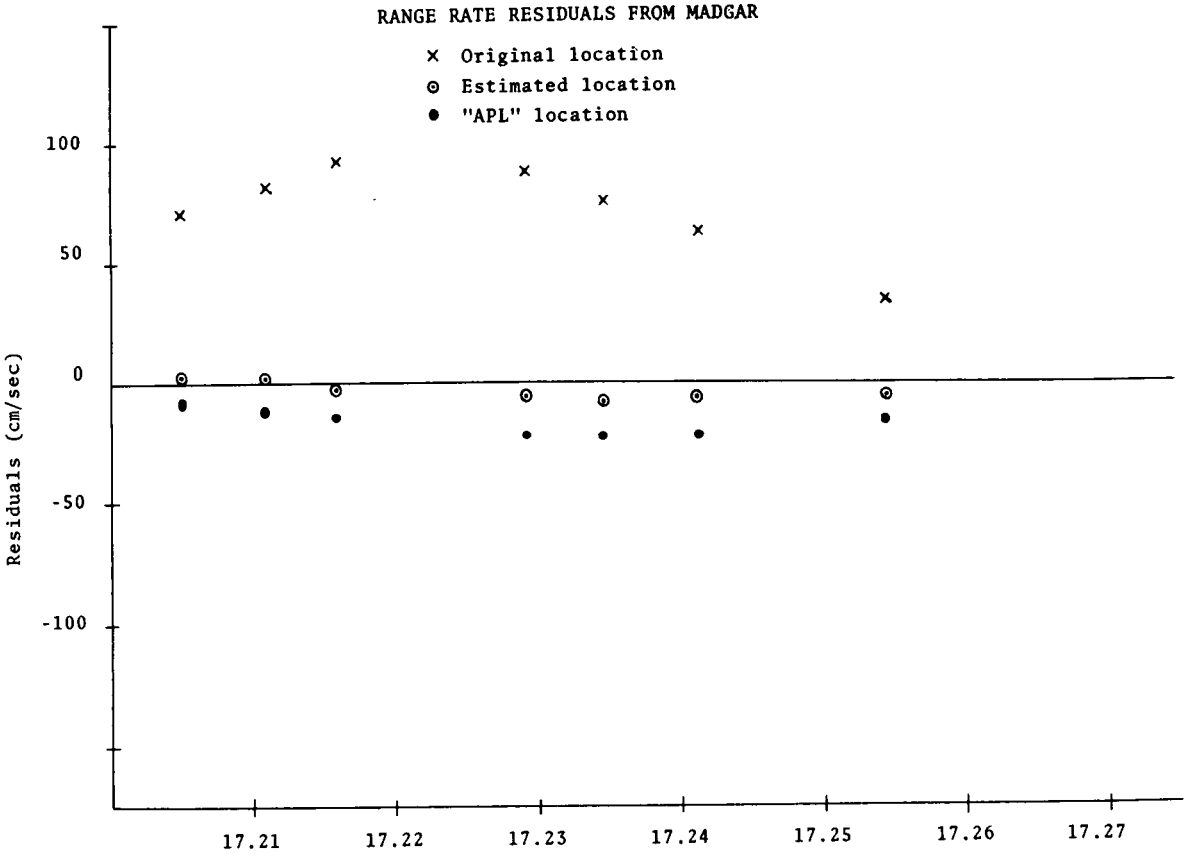

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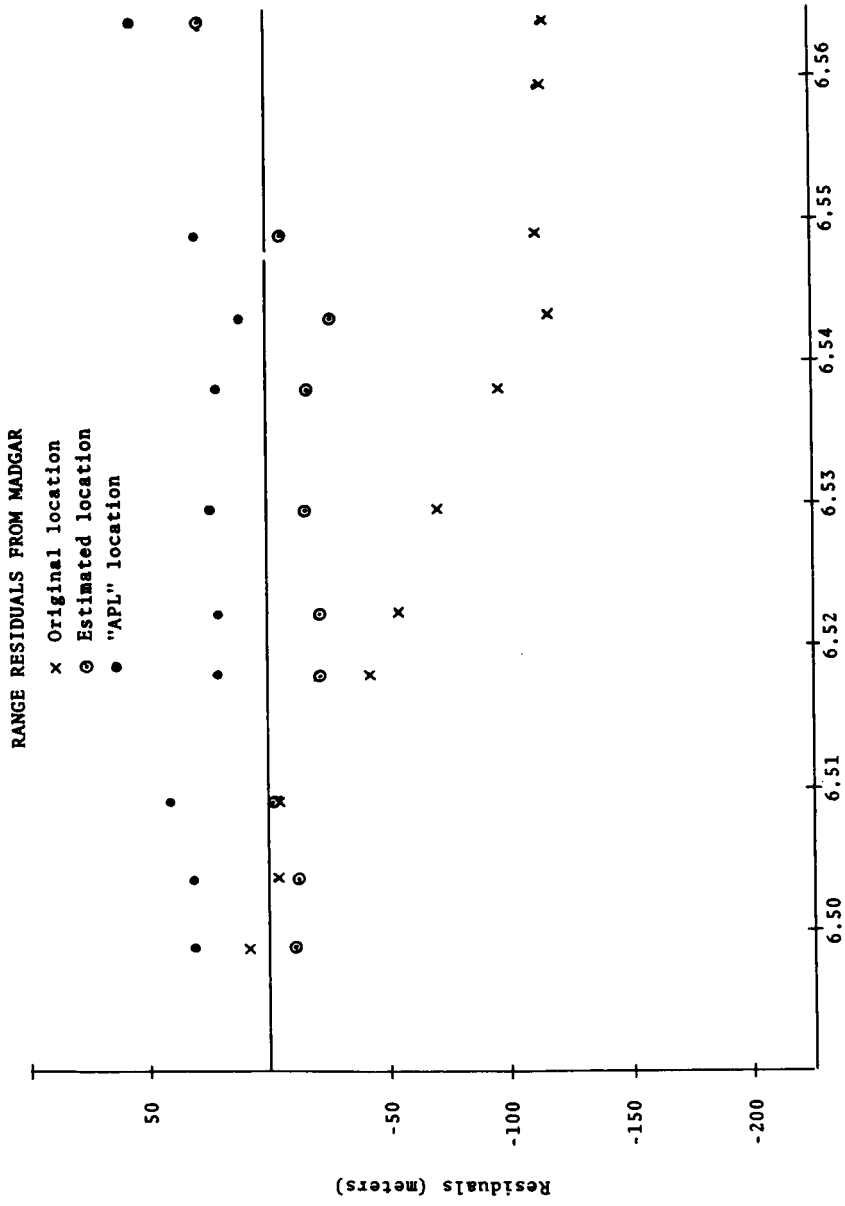
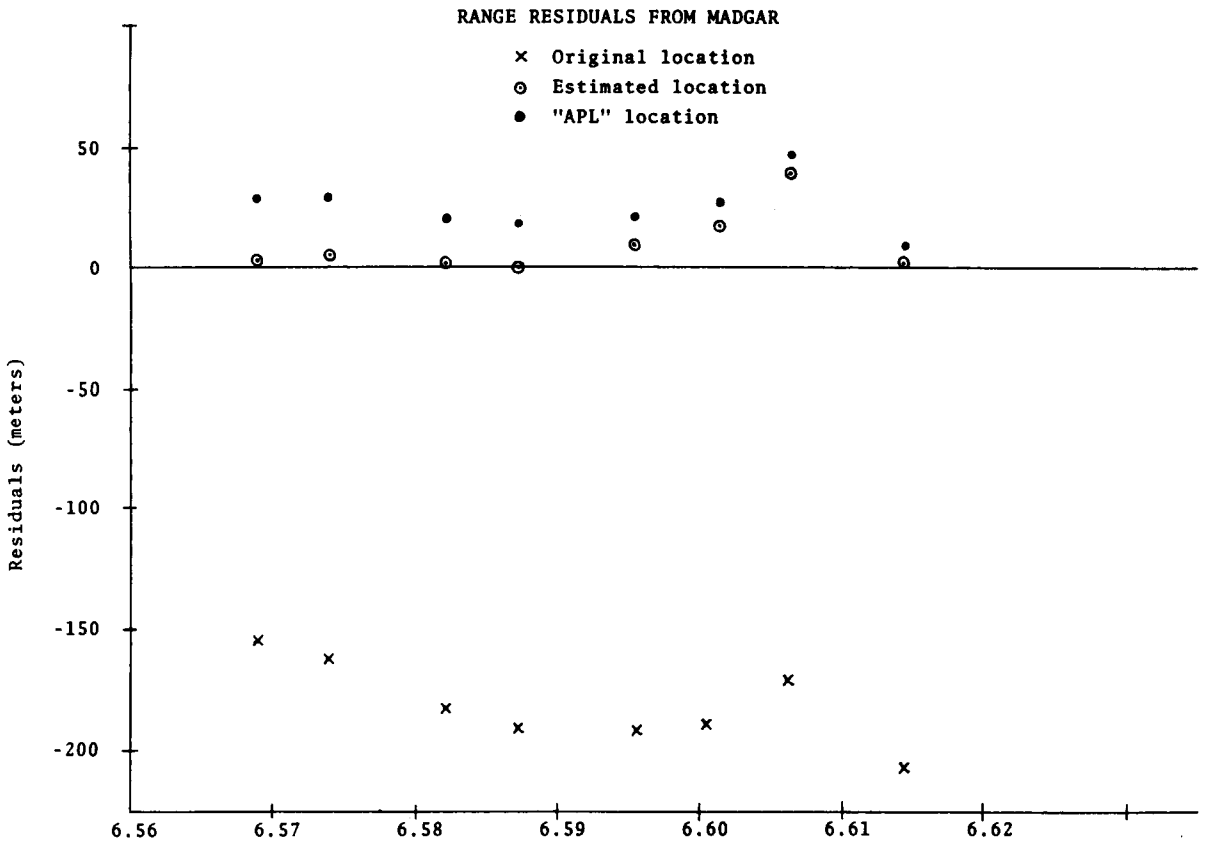


Figure 18. July 22, 1966



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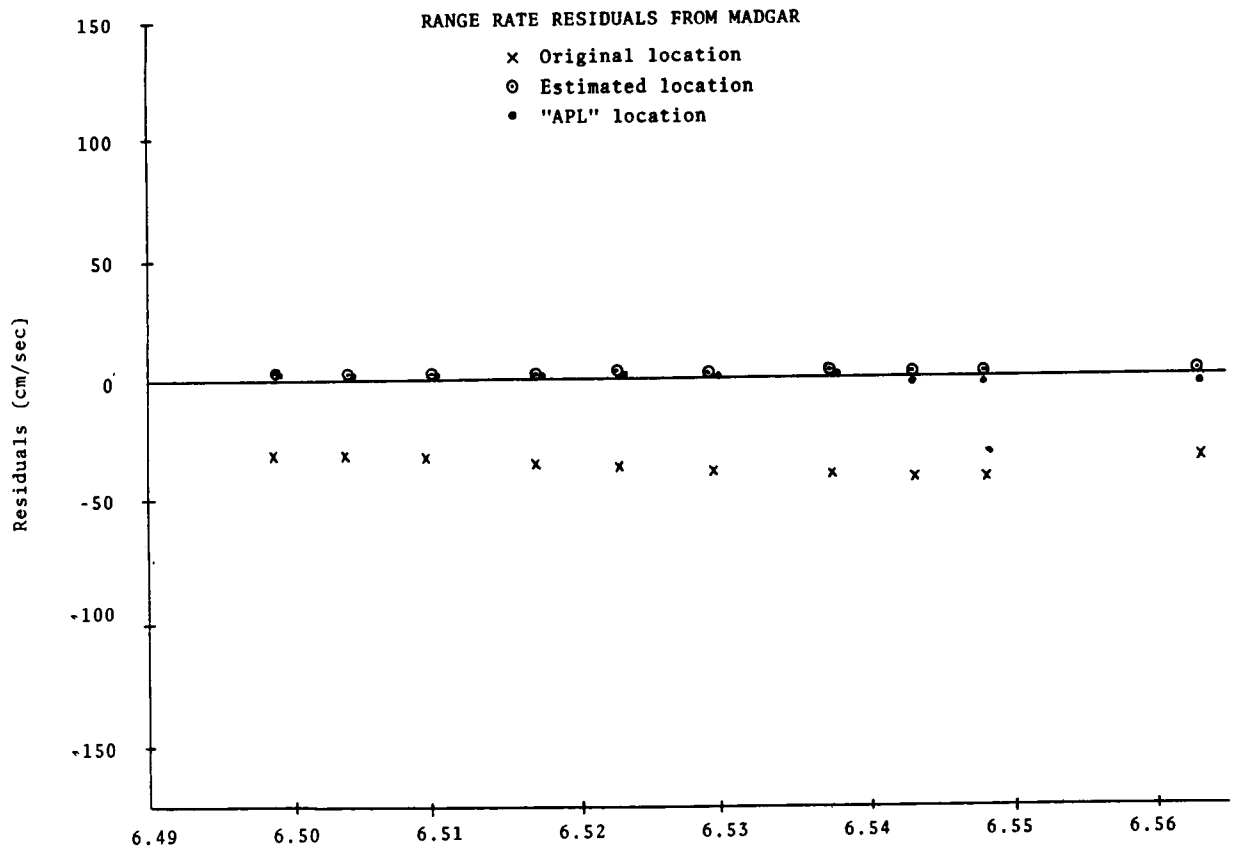

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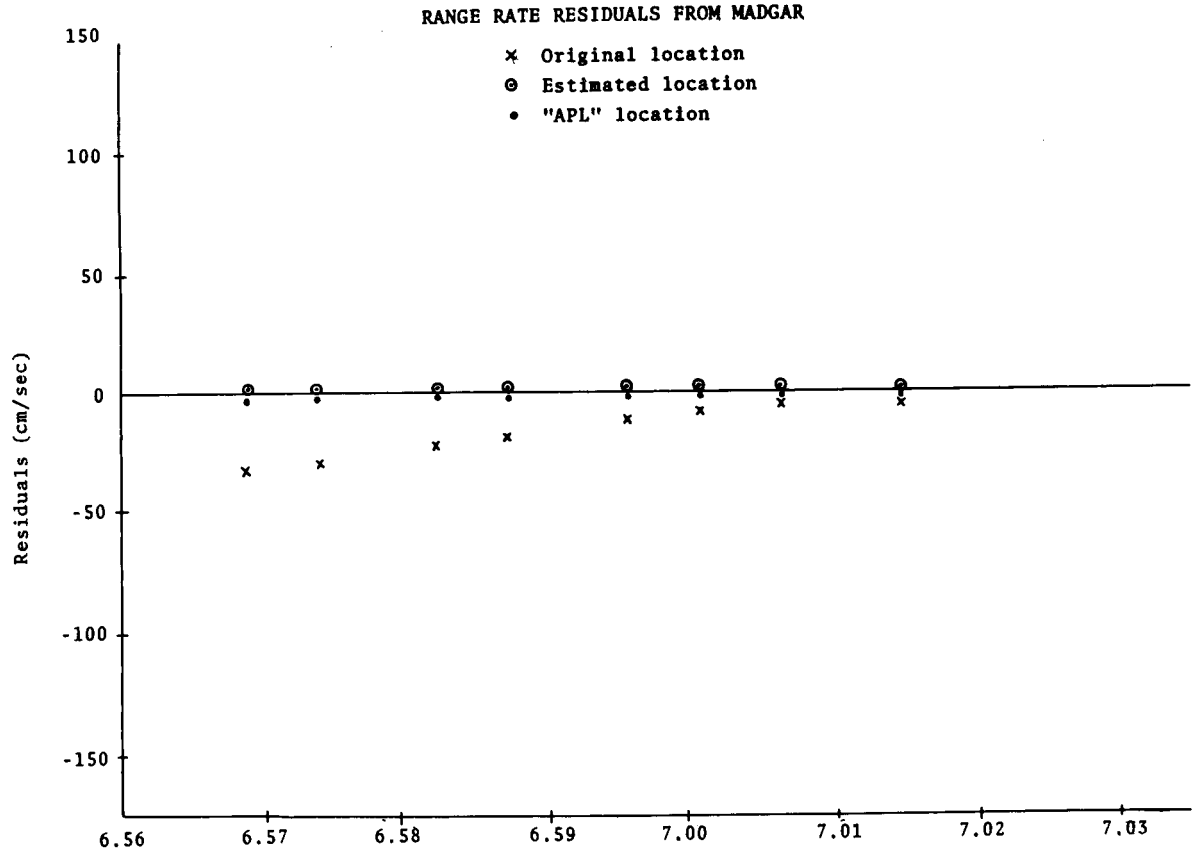

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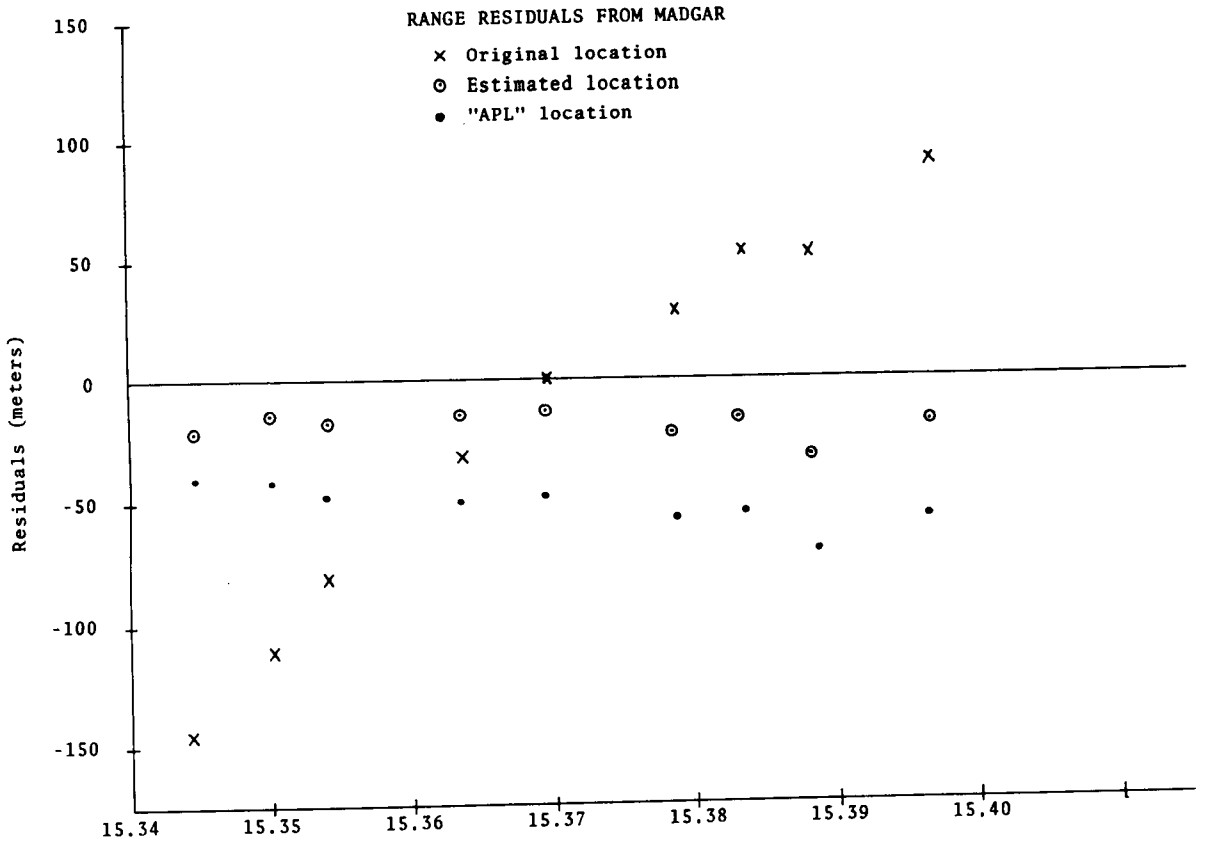

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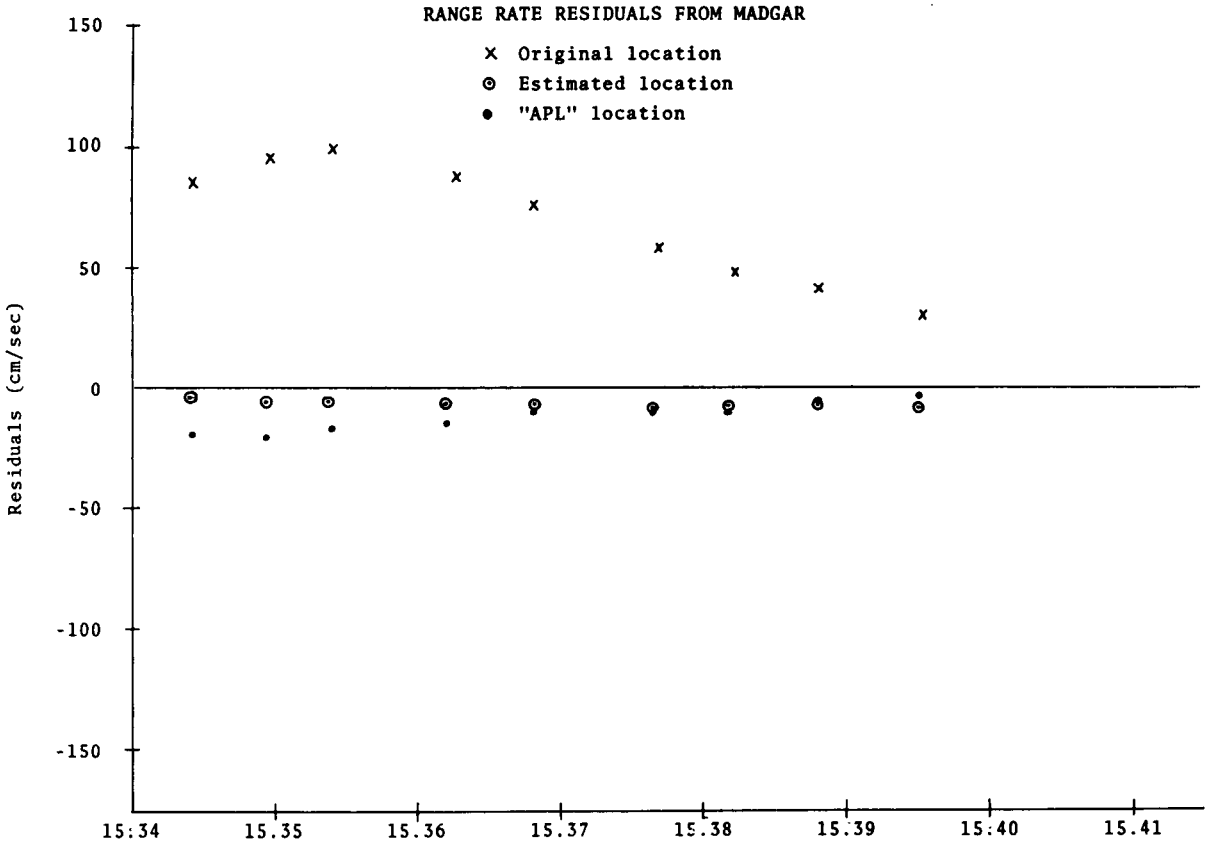

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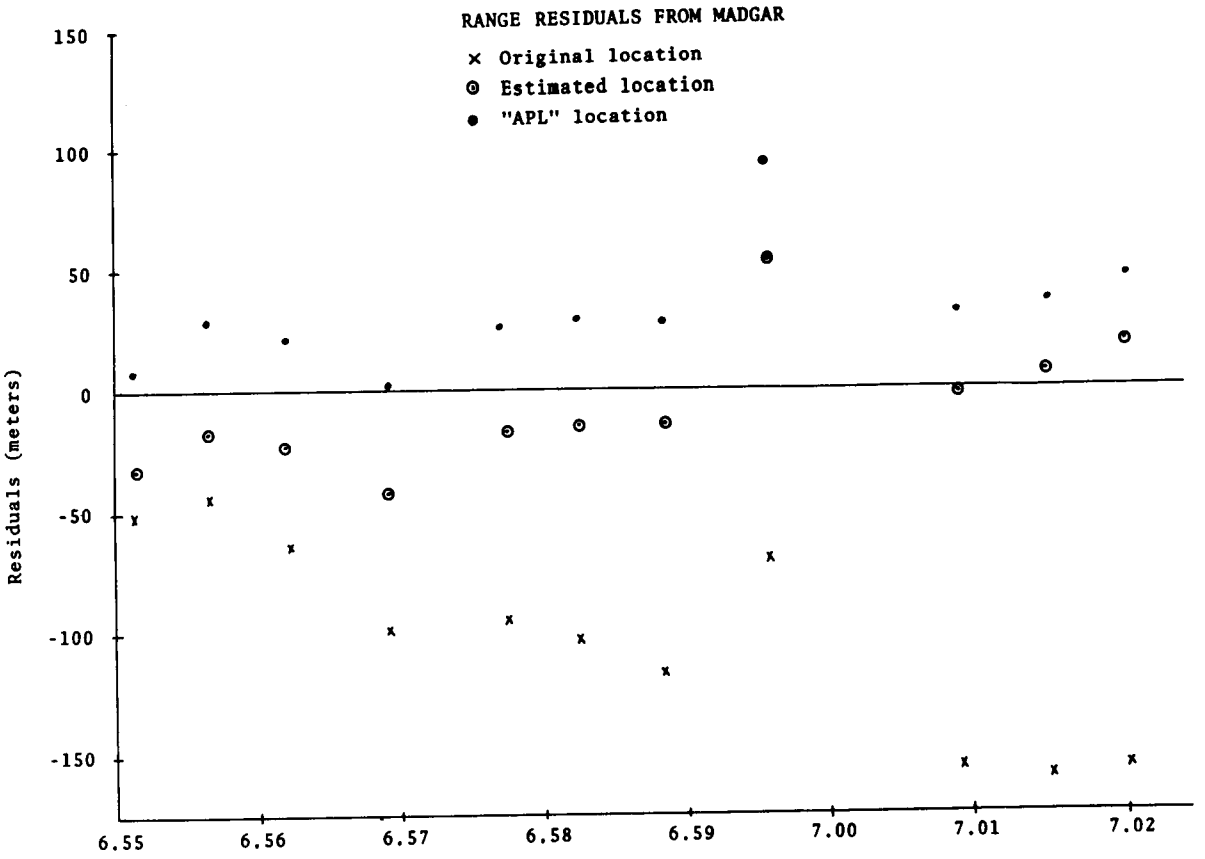

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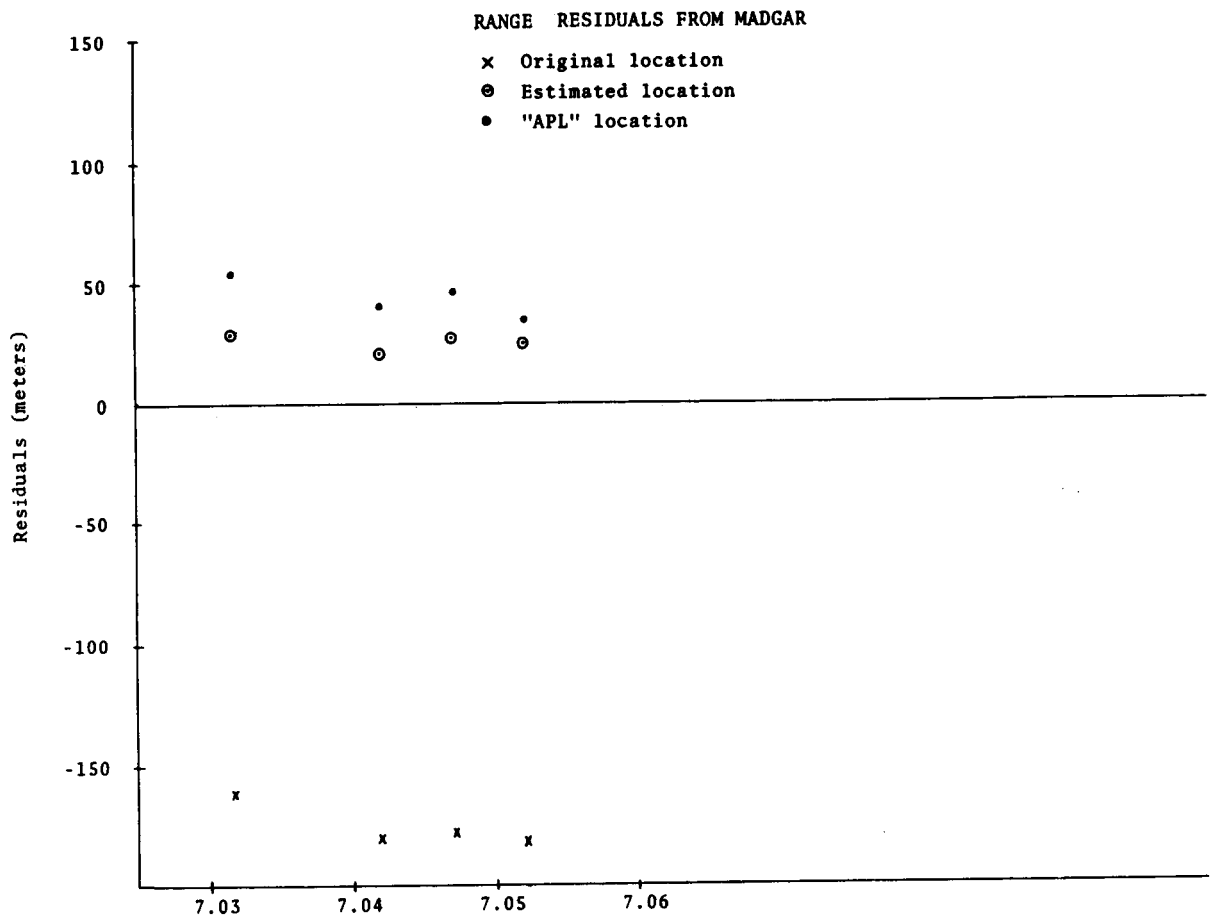

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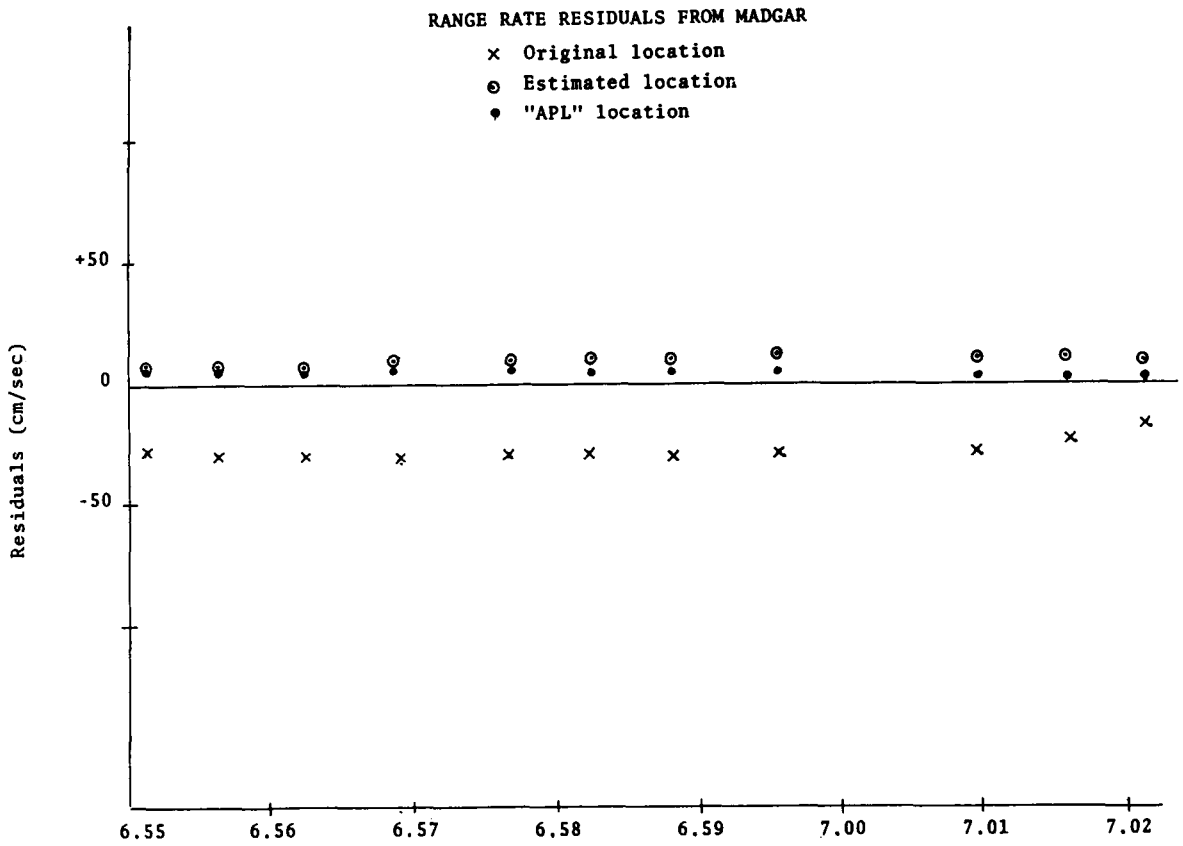

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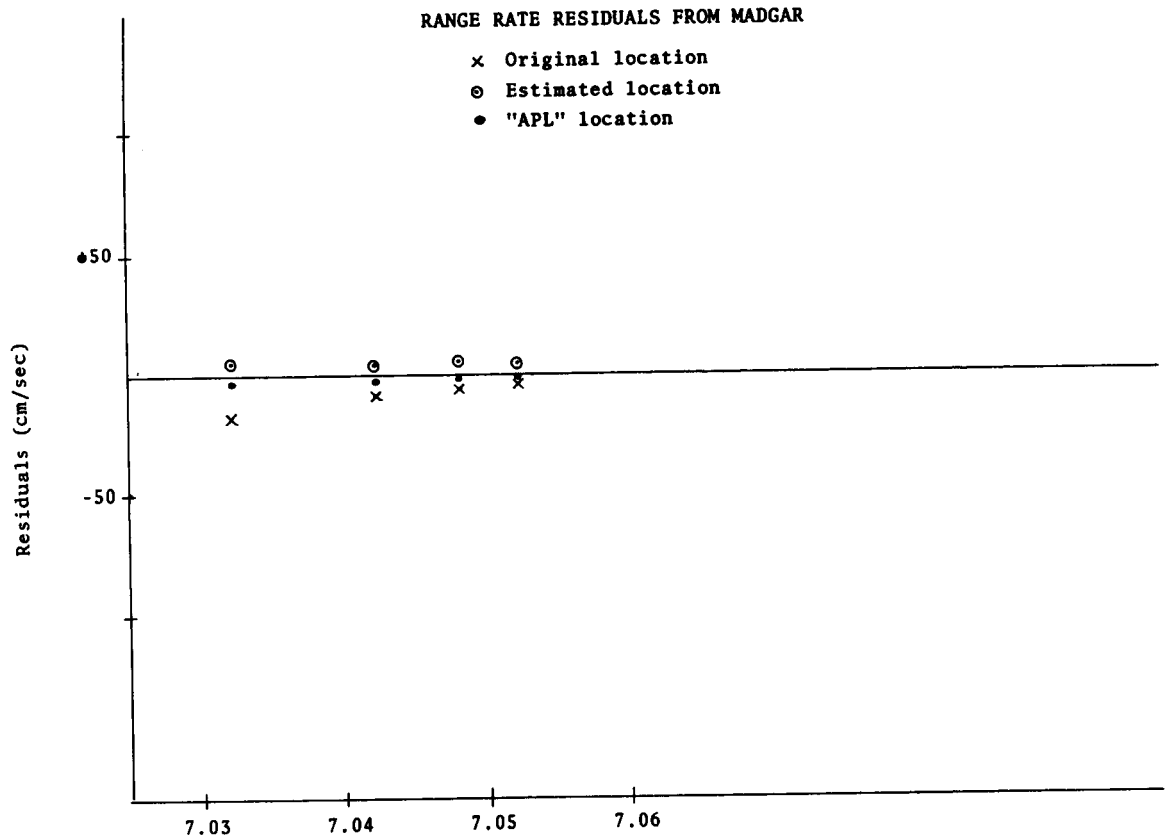

Figure 23 (Cont.). July 23, 1966

REFERENCES

1. NASA Contract Document:

Wolf Research and Development Corporation: Interim Status Report on Program Development and GEOS-A Data Analysis (NAS 5-9756-44A, 55, 71), August 1967.